Finnra

Cambridge Systematics, Inc., USA

Evaluation of Road Condition and Pavement Management in Finland

Final report and recommendations

Finnra
Reports
32/2000

Helsinki 2000

Finnish National
Road Administration
Financial Planning

Tielaitos
TIEHALLINTO

14.7.2000

841/2000/20/1

Jakelun mukaan

Päällystettyjen teiden kuntotilan ja ylläpidon ohjauksen arviointi

Tielaitos on teettänyt yhdysvaltalaisella konsulttitoimistolla tutkimuksen päällystettyjen teiden kunnosta ja niiden ylläpidon ohjauksesta. Tutkimuksessa tarkasteltiin Tielaitoksen päällystyspolitiikkaa, päällystettyjen teiden kuntotilaa ja rahoitustarvetta, näihin liittyvää toiminnan ohjausta ja viestintää sekä Tielaitoksen tienpidon ohjaus- ja hallintajärjestelmiä.

Selvitykseen johtaneita syitä olivat mm. Valtiontalouden tarkastusviraston tarkastuskertomus "Tiestön kehittäminen" (Tarkastuskertomus 11/98, VTV 1998), tienpidon rahoituksen aleneminen sekä tiestön kunnosta ja sen rahoituksesta käyty jatkuva keskustelu. Tavoitteena oli saada nimenomaan ulkopuolinen näkemys Tielaitoksen toiminnasta. Selvitys rajattiin koskemaan päällystettyjä teitä ja niiden päällysteiden ja rakenteiden kuntoa.

Tutkimuksen toteutti Cambridge Systematics Inc. (CSI), jota avusti teettämiskonsulttina toiminut Inframan Oy.

Kun Suomessa käytettiin vielä 1992-94 noin 1 000 milj. markkaa vuodessa yleisen tieverkon päällystettyjen teiden kunnossapitoon, vuosina 1998-99 näihin toimenpiteisiin on voitu kohdistaa enää reilut 600 milj. markkaa vuodessa. Tieverkon laajennus- ja uusinvestointien (kevyen liikenteen väylät, eritasoliittymät, melusuojaukset yms.) rahoitusvajetta on paikattu tinkimällä ylläpidosta ja korvausinvestoinneista.

Päällystettyjen teiden ylläpidon ja korvausinvestointien 600 - 620 milj. markan vuosirahoitusta tulisi tutkimuksen perusteella lisätä 720 - 760 milj. markkaan (vuoden 1999 kustannustasossa) päällystetyn tieverkon rappeutumisen pysäyttämiseksi. Lisäksi tarvitaan noin 500 milj. markkaa jo syntyneen jälkeenjäämän rahoittamiseksi.

Nykyinen toiminta johtaa liian pitkään päällysteiden uusimiskiertoon, jopa 12 - 16 vuoteen. Lisärahoituksella uusimiskierto lyhenisi 10 - 14 vuoteen ja laatutavoitteiden alittavien teiden määrä vähenisi nykyisestä 27 %.

Keskushallinto
Opastinsilta 12 A
PL 33
00521 HELSINKI

Puhelin
0204 44 150

Telefax
0204 44 2202

Sähköposti
etunimi.sukunimi@tielaitos.fi

Tielaitoksen päällystettyjen teiden ylläpito ja ohjaus on tutkimuksen perusteella hyvin hoidettua. Tielaitoksen tulisi kuitenkin laatia selkeä päällystettyjen teiden ylläpitopolitiikka ja suunnitella toimintansa ja asettaa tavoitteensa nykyistä pidemmälle aikavälille. Kuntoa ja tieverkon tilaa kuvaavat mittarit ja tunnusluvut tulisi raportoida nykyistä ymmärrettävämmiksi. Lisäksi Tielaitoksen tulisi parantaa kuntotilaan ja sen vaikutuksiin liittyvän viestinnän ymmärrettävyyttä.

Osa esitetyistä toimenpiteistä ja kehittämisprojekteista on jo käynnistetty Tielaitoksessa.

Kun päällystämisen ja maarakentamisen kustannustason arvellaan vuonna 2000 nousseen jo 10 - 20 %, esitetty rahoitustarve on näin ollen jo 830 – 875 milj. mk. Lisäksi jo vuoden 1999 loppuun syntyneen jälkeenjäämän kattamiseen tarvittaisiin 550 - 600 milj. markan lisärahoitus.

Päällystettyjen teiden kuntotilan ja ylläpidon ohjauksen arviointia koskevat alustavat tulokset on esitelty aihetta käsitelleessä seminaarissa 26.10.1999. Loppuraportti ja suositukset on julkaistu tutkimusraportissa "Evaluation of Road Condition and Pavement Management in Finland" (Finnra Reports 32/2000) ja sen käännöksessä "Päällystettyjen teiden kuntotilan ja ylläpidon ohjauksen arviointi" (Tielaitoksen selvityksiä 34/2000). Yksityiskohtaisemmat tarkastelut ja tulokset on esitetty neljässä erillisessä vain englanniksi toimitetussa tutkimusraportissa.

Selvitystyön aikana haastateltiin yhteensä 33 henkilöä, josta erityiskiitokset sekä yhteistyökumppaneille ja sidosryhmille että Tielaitoksen omalle henkilöstölle

Lisätietoja: apulaisjohtaja Jani Saarinen (p. 0204 44 2436) ja apulaisjohtaja Raimo Tapio (p. 0204 44 2204).

Apulaisjohtaja
Esikunta

Jani Saarinen

LIITTEET

Päällystettyjen teiden kuntotilan ja ylläpidon ohjauksen arviointi / Evaluation of Road Condition and Pavement Management in Finland

JAKELU

Eduskunnan liikennevaliokunta
Eduskunnan valtiovarainvaliokunnan liikennejaosto
Liikenneministeriö
Valtiovarainministeriö

Asfalttiliitto
Kuntaliitto
Maarakennusalan neuvottelukunta MANK
Metsäteollisuus, Harri Rumpunen
Oulun yliopisto, Tie- ja liikennetekniikan laboratorio
Päällystealan neuvottelukunta PANK ry
Suomen Kuorma-autoliitto ry SKAL
Suomen Maarakentajien Keskusliitto ry SML
Teollisuus ja työnantajat TT
Tieyhdistys
TKK, Rakennus- ja ympäristötekniikan osasto
TTKK, Liikenne- ja kuljetustekniikka
Valtiontalouden tarkastusvirasto VTV
VTT / Yhdyskuntatekniikka

Tielaitoksen johtokunta
Tielaitoksen johtajat
Tiepiirit
Keskushallinnon yksiköt
Tuotannon konsultointi
Tuotannon konsultointi, tiestötietopalvelut
J. Pulkkanen, O. Penttinen, J. Sammallahti, T. Toivonen,
N. Tykkyläinen / Hos
K. Eskola, K. Lehtonen, T. Kallionpää, M. Reihe / Htl
Iso-Heiniemi, J. Meriläinen, R, Prokkola, P. Virtala / Hti
J. Saarinen, R. Tapio, I. Komsi / Hek
Tielaitoksen kirjasto

Cambridge Systematics Inc.
Inframan Oy
Tutkimuksessa haastatellut henkilöt

Jani Saarinen
M:\Hek\KIRJEET\2000\Muut\Cambridge_lähete.doc

Finnra Reports
32/2000

Cambridge Systematics, Inc., USA

Evaluation of Road Condition and Pavement Management in Finland

Final report and recommendations

**Finnish National
Road Administration**

Helsinki 2000

ISBN 951-726-662-6

Oy Edita Ab
Helsinki 1999

This Publication is available from:
Finnra, Financial Planning

Finnish National
Road Administration
Opastinsilta 12 A
P:O. Box 33
00521 Helsinki, Finland

Evaluation of Road Condition and Pavement Management in Finland. Helsinki 2000. Finnish National Road Administration, Finnra Reports 32/2000, p. 34 + appendix p. 1, ISBN 951-726-662-6, TIEL 3200620

Key words condition, pavement, maintenance, rehabilitation, financing, HIPS, PMS

ABSTRACT

Finnish National Road Administration (Finnra) carried out an international study to clarify the impacts of budget reductions in pavement maintenance on the national highway network, to identify an appropriate level of annual investment in the pavement program, and to assist Finnra management in dealing with policy, mangement, communication, and technical issues related to the pavement program. The study was conducted after an international bid by Cambridge Systematics Inc. from USA. The main objective was to get an objective and external view of the pavement management of Finnra. The study included all the paved roads and their structural condition.

The length of the entire road network managed by Finnra is about 78 000 km of public roads. Some 50 000 km of this network is paved. The budget to maintain this paved portion of public roads was about 1 billion FIM annually in 1992-94. However, during 1998-99 this budget has reduced to only 600 million FIM per year. The reduction of the maintenance budget of Finnra was due to the overall decrease of Finnra's budget but as well the shift from maintenance to new investments.

The study included the interview of the managers and experts of Finnra, the representatives from the Transport and Finance Ministries, and those from the State Audit Office and the Finnish Research Center. Also the representatives of several interest groups and contractors were involved in the study. Altogether, the number of interviewed was 33 persons.

The consultant gathered a considerable amount of information of the recent history of the pavement program, standards, guidelines, quality requirements, and pavement management systems used for assessing the deterioration of pavements and need for future financing. The evaluated systems included HIPS (Highway Investment Programming System, network level PMS), PMSPro (project level PMS), and KURRE (pavement condition data bank). The comparative calculations and analysis were also made with the consultant's own assessment systems.

The findings of the study were reported in four different areas: pavement policy, program management, communication, and technical information. In addition, four separate technical reports were produced: Pavement Condition: Measures, Models and Criteria; Trends in Asphalt Pavement Performance: Comparisons Among Regions and with Pavement Prediction Models; Use of the Highway Investment Programming System: Analysis of Models and Results; Organizing, Communicating and Applying Pavement Program Information: Review of Management by Objectives and Role of Finnra Management Systems, and Recommended New Ways to Communicate Information.

Current funding levels for pavement maintenance of 600-620 million FIM per year are not optimal and will lead to a worsened paved network condition in the future. The appropriate investment level is 720-760 million FIM per

year over the long term, with an additional 50 million FIM per year for 10 years needed to reduce the accumulated backlog of needed pavement work. Continued funding at today's level will result that the interval between pavement actions will remain at 12-16 years compared to the 10-14 year intervals with the optimal funding level. The length of substandard pavements in the network would also decline to a 27 percent reduction from the current level with the increased budget.

There is no evidence of a "time bomb" in the sense of a sudden, severe decline in pavement condition nationally. However, different subsets of the pavement network will be affected differently by the reductions in budget levels that have occurred. If the budget falls below the today's level it will cost additional amounts to restore the network to the optimal condition.

The optimization method, minimization of total life-cycle costs, used by Finnra provides a correct economic criterion for highway investment decisions. This criterion is used by many transportation agencies throughout world. Finnra decribes the condition of the paved network with the parameters like rut depth, roughness, defects, and bearing capacity. These parameters and their measurement techniques are valid and used by many transportation agencies around the world as well.

Management by objectives procedure works well according to this evaluation study. Finnra's mechanisms for translating objectives into results, and for reporting actual vs. target products and costs, for the most part appear to work well internally. However, these technical interpretations need to be expressed in a way that are more understandable and meaningful for policy and budget discussions. There is also a need for Finnra's directors to reach a consensus on pavement management policy and to communicate that management decision in a consistent manner to parties outside of Finnra. In addition, setting pavement targets for a 3-5-year project plan, rather than annually, would encourage more effective project definition.

Analytically, Finnra's pavement management systems (HIPS and PMSPro) are technically advanced and correspond to the state of the art among facility management systems used by other road authorities throughout the world. However, the utilization of the existing management systems in Finnra is not carried out to full extent. The existing condition parameters describe only the number of substandard pavements and not the existing condition state and distribution of paved network. So, the existing condition parameters are recommended to be simplified.

The communication and application of pavement data within Finnra is effective. It is the communication of paved network information outside of Finnra that deserves attention. The non-technical descriptions of pavement condition that encompass the entire network, not only the substandard pavements should be adopted. These descriptors should also be related to the consequences or impacts of pavement condition. These may include, for example, socioeconomic objectives relating to preserving the value of the highway assets as much and as long as possible, to objectives of economic competitiveness relating to freight and business travel. These impacts should be described in relation to the alternative funding levels.

The technical systems and descriptors were also recommended to be improved. The pavement condition should be expressed in a non-technical way by using the terms of excellent, good and poor instead of very technical definitions. The predicted trends of project-level models are realistic compared to actual performance. As the predicted pavement deterioration in the network-level model (HIPS) underestimates observed pavement damage.

The study concludes that Finnra has organized and implemented an effective process of management-by-objectives (MBO) for its pavement program. However, Finnra should formulate a clear pavement management policy which identifies the short-term and long-term investment needs, impacts on pavement condition by sub-network, consequences of these resulting pavement conditions in terms of costs, benefits to passenger and freight users, as well as, to reach a consensus by Finnra's directors in communicating this policy internally and externally. Some of these recommendations have already been implemented.

FOREWORD

Finnish National Road Administration (Finnra) decided to carry out an extensive performance review of its highway pavement program (Evaluation of Road Condition and Pavement Management in Finland) in spring 1999. The reasons for this performance review were:

- State Audit Office report (Development of the Finnish Road Network, Inspection Report 11/98, VTV 1998),
- Statement by the Ministry of Finance on the previous report which recognizes the contradictory forecasts of the future financing needs stated by Finnra, and also recommends the use of external auditors,
- Decrease of road maintenance funding in the 1990's,
- Public debate on the condition of paved roads and level of maintenance funding
- Statement in the Finnish Government's policy program to retain the condition and value of asset of the public road network, and
- The deficiencies in the management by objectives between the Ministry of Transport and Finnra.

The international bid was arranged for the implementation of the evaluation project in spring 1999. The Finnish contractors and consulting companies were not included in the bid because they were thought to be too close to Finnra activities and views. The objective was to find an auditor with objective and totally external view on the subject.

The bid was sent to nine different consulting companies, universities and research centers from the Nordic Countries, England, France and United States. Cambridge Systematics Inc. (CSI) from USA was selected to perform the audit. The main authors of this report as well as of the evaluation project were Lance A. Neumann (Ph.D.), Michael J. Markov (M.Sc.) and Bill Robert (S.M.).

The Finnish Consultant (Inframan Ltd.) was used in preparing the contract documents and in helping CSI to gather data and other information for implementing the review. Ari Kähkönen (M.Sc.) and Vesa Männistö (M.Sc.) from Inframan Ltd. participated in the project. However, all the conclusions and recommendations in this report are made by CSI.

The persons responsible of the project in Finnra were Deputy Director Jani Saarinen and Deputy Director Raimo Tapio from Finnra Staff. Ms Tarja Järvinen was responsible of the research arrangements and of the lay-out of this report.

Altogether 33 persons were interviewed during the evaluation. Finnra expresses its sincere thanks to these people representing several government authorities, partners and customers of Finnra as well as Finnra personnel.

The preliminary results of the study were presented in the seminar in October 1999. This report presents the executive summary and the final results of the entire study. Four separate technical reports were also produced during the project which contain the more detailed results and recommendations for the improvement of the Finnish highway pavement program.

Helsinki, June 2000.

Jani Saarinen
Deputy Director
Financial Planning

Raimo Tapio
Deputy Director
Financial Planning

CONTENT

1 INTRODUCTION

1.1 Study Objectives

This report documents a performance review and evaluation of the highway pavement program of the Finnish National Road Administration (Finnra). The study, which was requested and funded by Finnra, was undertaken to clarify the impacts of budget reductions in pavement maintenance on the national highway network, identify an appropriate level of annual investment in the pavement program, and assist Finnra management in dealing with policy, management, communication, and technical issues related to the pavement program. The key objectives of this study were as follows:

- To review and evaluate Finnra's pavement program and policies;
- To review the adequacy of current levels of pavement investment;
- To assess management procedures, analytic tools, and data and assumptions that Finnra uses to establish pavement policy, and to manage and budget its pavement program;
- To assess the effectiveness of Finnra's communication of information regarding its pavement program; and
- To evaluate selected technical components of pavement program management.

For purposes of this report, the terms "pavement maintenance" and "pavement investment" will refer to those activities needed to preserve the pavement in good condition, prevent or correct damage to the pavement surface or structure, and provide a safe, smooth riding surface for motorists. Construction of new pavement to expand existing highway capacity or to provide new capacity has not been addressed in this review.

1.2 Conduct of Study

Study Team

Cambridge Systematics, Inc., of Cambridge, Massachusetts, U.S.A., has conducted this study under contract to Finnra. Cambridge Systematics is a consulting firm that specializes in transportation systems management, economics, and information technology. The firm has assisted many transportation agencies in the U.S. and internationally in improving their methods and procedures to manage transportation assets more effectively. With respect to program evaluation specifically, Cambridge Systematics has conducted performance reviews and audits of several agencies regarding transportation programs in highways and railways.

Inframan Oy of Espoo assisted Cambridge Systematics in this effort, under a separate agreement with Finnra. Inframan Oy provided local assistance and support in several tasks involving modeling and data analysis.

Groups Participating in Study

Issues surrounding Finnra's pavement program funding and management have attracted the interest of a number of organizations. In conducting this study, Cambridge Systematics interviewed and gathered information from many sources, including the following:

- Directors, managers, and technical staff in Finnra's central administration and in two regions: Häme and Kaakkois-Suomi.
- Staff of Finland's Ministry of Finance and Ministry of Transportation and Communications.
- Staff of the State Audit Office, which had conducted an earlier review of Finnra's pavement investment policies.
- Several road industry firms and associations representing construction and materials interests.
- Groups representing business, commercial, and other road users, and a regional planning organization.
- Finland's national research agency, VTT.

Study Approach

Finnra requested that this review and evaluation be conducted essentially as a performance audit. A considerable amount of information was gathered to develop an understanding of the recent history of the pavement program, issues that were felt to be important by different parties, options that might be considered for program policy, and potential consequences of different courses of action. The study team was encouraged to meet with as many interested groups as possible (as indicated above), to obtain a comprehensive understanding of different perspectives on the pavement program.

The duration of this study extended from June 1999 through November 1999. Most of the information needed for the review and evaluation was obtained during three visits by the study team to Finland for interviews and data gathering. Technical information was also provided by Finnra staff from management systems and databases. Inframan Oy assisted by obtaining additional documents and translating relevant sections of key documents.

While many individuals contributed to this study and assisted in the analysis of data, the study team compiled the data, conducted its own independent analyses, and developed the findings and recommendations that are cited in this report.

1.3 Report Organization

Subsequent chapters of this report develop background information and address the major questions posed by Finnra at the beginning of the study. Report organization is as follows:

- Chapter 2 provides additional background and historical information on the pavement program, and lays out the different perspectives cited by the several groups that were interviewed.
- Chapter 3 provides the study's findings in pavement program policy. It responds to the following questions posed by Finnra:

  Is the road maintenance budget adequate now and in the long term?

  If not, what level is appropriate?

  What are the consequences of these different budget scenarios?
- Chapter 4 provides the study's findings on pavement program management. It responds to the following question posed by Finnra:

  How well do current procedures for Management by Objectives (MBO) operate?
- Chapter 5 provides the study's findings on communication of pavement program information. It responds to the following question posed by Finnra:

  Is Finnra's communication of information about the pavement program accurate, credible, consistent, and understandable?
- Chapter 6 summarizes the study's findings on technical aspects of the pavement program. It responds to the following question posed by Finnra:

  Are current elements of pavement program management effective and reliable?
- Chapter 7 concludes the report and provides overall recommendations.

2 STUDY BACKGROUND AND PERSPECTIVES

2.1 Recent History of the Pavement Program

Finnra manages a road network totaling 78,000 kilometers, of which about 50,000 km are paved. Paved surfaces are of two types: asphalt concrete (AC), and soft-asphalt concrete (SAC), also referred to also as oil-gravel pavement. In general, AC pavements are used on motorways, other main roads, and roads with high traffic volumes, while SAC pavements are used on the more lightly traveled routes.

Expenditures for pavement maintenance have declined in the past decade, as indicated in Table 1. The effect of this reduction on pavement condition is shown in Figure 1, where pavement condition is measured using Finnra's current definition of "substandard" pavements: i.e., pavements in which one or more measures of deteriorated condition have exceeded a defined threshold limit.[1] The trends in Figure 1 indicate the following:

[1] Measures of deterioration for AC and SAC pavements in Finland include roughness, rutting, and sum of defects (e.g., cracking, potholes, and other surface defects).

- At the start of the decade, pavement condition was improving: i.e., the length of substandard pavement nationally was declining, as substandard pavements were repaired or renewed.
- With the subsequent reduction in pavement maintenance funding, the trend in pavement condition initially showed no change. This situation is not unexpected, since the impacts of pavement maintenance are long-term, and responses to changes in investment level may be delayed.
- By 1995, however, the trend in condition had indeed reversed, and the number of kilometers of substandard pavements began to increase.

The current objective that Finnra has negotiated with the Ministry of Transport is to limit substandard pavements to the 1999 amount of not more than 6,400 km.

Table 1. Pavement Maintenance As a Percentage of Total Road Expenditures

Year	Pavement Maintenance, Mmk	Percentage of Road Budget
1993	1,100	20%
1999	600	14%
2000	620	15%

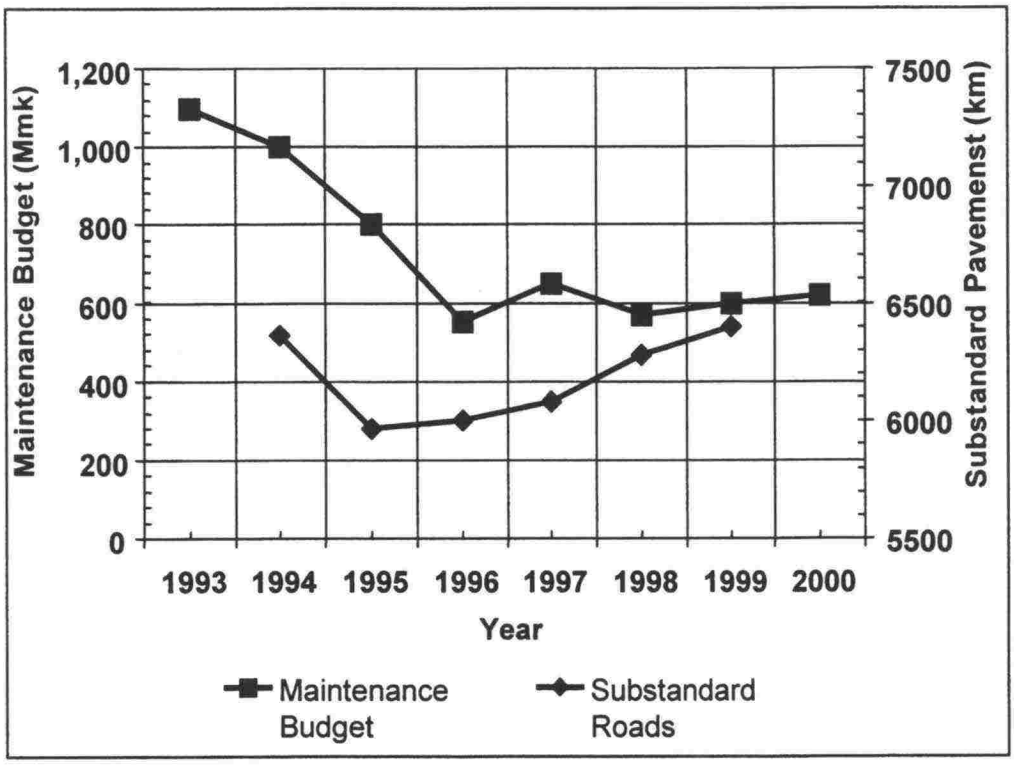

Figure 1. Pavement Maintenance and Length of Substandard Pavements

2.2 Results of Interviews and Surveys

Table 1 and Figure 1 show that that annual funding of pavement maintenance is now one-half of the peak level experienced earlier in the decade. Interviews conducted during this study demonstrated that different groups have markedly different perspectives on what this reduction implies, and how critical a situation it represents. Following is a summary of the comments by Finnra, the Ministry of Transport and Communications and Ministry of Finance, and various private sector associations and representatives.

Concerns Regarding the Funding Decline

Concerns regarding the funding decline were expressed by road user representatives, pavement industry groups, commercial and transport interests, and some (but by no means all) Finnra managers in central administration and the regions. In fact, our finding was that Finnra management in general did not hold a unified opinion on the meaning, consequences, and implications of the reduction in pavement maintenance funding.

Among those who did express concerns about the funding decline, the problems most often cited were as follows:

1. There is a fear that the gains achieved through increased pavement investment and the resulting improvement in pavement condition in the early 1990s (Figure 1) may be lost.
   - An example that was often cited to support this fear was the history of disinvestment in the Finnish railroad, which subsequently required a substantial increase in capital funds to restore satisfactory condition of the system.
   - The analogy for highways is that if current trends continue, a future "time bomb" in deteriorating pavement condition will develop, especially on the lower-standard roads.

2. A worsening pavement condition detracts from the ability of the highway network to meet current and future transportation needs. Several of those who were interviewed cited the following examples of potential impacts of a continuing reduction in pavement condition:
   - A possible impact on the competitiveness of Finnish industries, recognizing the higher-than-average percentage of logistics costs that are attached to Finnish goods.
   - Reduced transportation benefits to road users.
   - A reduced ability of the highway to support the structural loads of EC-standard truck weights and to accommodate changes in vehicle technology (e.g., "super-single" tires).
   - A reduced ability of the road system to serve changing demand for transportation due to demographic shifts in population and travel demand.

While these concerns were cited by several groups, there has been very little quantitative analysis of these topics in an engineering or an economic context.

Ministerial Perspectives

Interviews with both the Ministry of Transport and Communications and the Ministry of Finance provided additional historical background on the budget reductions, and established the broad context within which financing decisions and allocations among transportation sectors are made. A summary of these perspectives is as follows:

- The economic depression that occurred in the early 1990s and its effects on national government revenues forced many difficult budget cuts. Deep reductions were incurred by programs across the public sector, not just in road transportation.
- Ministerial staff raised the possibility that past highway funding had been too high relative to needs in other programs, and that recent reductions in this funding levels represented a correction.
- Finnra has not fully justified its recommended level of investment in pavement maintenance, in terms of economic or other consequences of reductions in pavement maintenance.

Results of Customer Survey

Prior to the start of our study, Finnra had commissioned a customer survey of highway levels of service. This survey covered many elements of highway performance, including the smoothness of traffic flow, level of winter maintenance, visibility and traffic conditions in intersections, and condition of pedestrian and bicycle ways, in addition to the perceived quality of pavements. Notwithstanding the large number of highway features and characteristics included in the survey, respondents ranked pavement condition of the main roads as one of the most important components of level of service.

All groups of road users agreed that paving on main highways is at a satisfactory level. However, the condition of paving on other roads is rated at a clearly lower condition. Moreover, those motorists that tend to use the highways more frequently, including drivers of commercial vehicles, rate the condition of these other pavements lower than do more occasional drivers or non-motorists. Pavement condition on the lower-standard roads was judged by road users to be one of the most important development items: i.e., road features that exhibit lower-than-average level of condition, and higher-than-average urgency for action. These survey results are consistent with and reinforce the findings in our interviews regarding (1) the relative importance of pavement condition in perceptions of highway quality and service level, and (2) the increasing disparity in relative condition of pavements between higher-standard and lower-standard roads.

Implications for Study

Having identified these different perspectives, we reviewed and evaluated the pavement program in the areas of policy, management, communication,

and technical items. Findings in each of these areas are discussed in the four chapters that follow.

3 FINDINGS ON PAVEMENT POLICY

3.1 Adequacy of Pavement Maintenance Budget

One of the key objectives of the study was to assess the adequacy of the road maintenance budget, now and in the long term. Resolution of this question was based upon the study team's analysis of results generated by Finnra's Highway Investment Programming System (HIPS). HIPS is a package that is used by Finnra to analyze long-term pavement investment strategies. HIPS can be used to identify optimal investment programs based upon specified budget constraints and the degree to which user costs and benefits are considered in the solution. Our findings on this issue are as follows:

- Recent budget levels (in the range of 600-620 Mmk per year) do not provide an optimal level of investment when user costs and benefits are considered.
- Continued funding at this level will result in the following:
  - The interval between pavement actions will remain at 12-16 years, compared to 9-12 years earlier in decade. As a result, the network condition will continue to worsen.
  - There will be a 40 percent increase in substandard roads, to about 8,900 km.
  - Substandard pavements will occur primarily on low-volume roads given current practices.
  - Potential impacts on economic competitiveness, ability to carry EC truck weights, and flexibility to respond to shifts in transport demand would need to be evaluated separately.[2]

The appropriate budget level was also estimated by analyzing the results of different HIPS cases, with the following findings:

- 720-760 Mmk is the optimal level of annual pavement investment to maintain expenditures and level of service at the most cost-effective level.
  - This is an increase of 20 percent above current budget levels.
  - The interval between pavement actions would be 10-14 years at this optimal level of funding.
- The length of substandard pavements in the network would decline to 4,650 km, a 27 percent reduction from current level.
- Before this long-term result can be achieved:
  - A backlog of pavement work that has accumulated during recent years must be corrected.

[2] Models of pavement deterioration in HIPS would need to be calibrated to different compositions and characteristics of traffic to analyze changes in traffic loads. These modifications require some analytic effort and time for Finnra to accomplish.

  - The backlog should be reduced by an extra 350 km/yr, at a cost of 50 Mmk/yr, for 10 years.
- Finnra needs to formulate policy targets in terms of both short-term (backlog elimination) and long-term needs, and then pursue adequate funding annually to maintain those targets. Policy formulation and communication must be proactive rather than reactive.

3.2 Pavement Policy and the "Time Bomb"

The study team investigated whether there is evidence of a "time bomb" threatening future pavement condition. This analysis was based not only on the HIPS results above, but also on a review of pavement condition data obtained from Finnra's Road Condition Data Bank. The analysis of average pavement trends was conducted for AC and SAC pavements, at a national level and for each region, for each component of pavement condition (roughness, rutting, and sum of defects). The findings of these analyses are as follows:

- There is no evidence of a "time bomb" in the sense of a sudden, severe decline in pavement condition nationally.
- However, different subsets of the pavement network will be affected differently by the reductions in budget levels that have occurred. Specifically, given current pavement maintenance policies, pavements on lower-standard highway classes will bear a greater degree of the deterioration in condition than those pavements on higher-standard highways.
- The most cost-effective strategy is to move toward and reach an optimal level of investment for the pavement network overall, and to remain at that level from year to year.
- If the budget falls below this level, however, it will cost additional amounts to restore the network to the optimal condition. This additional cost occurs because of the need to correct the backlog of deteriorated pavements that accumulates when the network is not maintained at the optimal level of investment.

3.3 Economic Analysis of Investments

Finnra's pavement decision support systems and criteria are based upon economic analyses of long-term costs. As part of the policy review, the question was posed as to whether the principle of economic optimization (minimization of life- cycle agency and user costs) is the right one. Our findings are as follows:

- Minimization of total life-cycle costs provides a correct economic criterion for highway investment decisions.
  - This criterion is used by many transportation agencies throughout world.
  - It enables one to make valid decisions among different options in pavement investment, in terms of types of activities, the timing of activities, or the location of these activities throughout the network.

- Economic analysis provides an objective basis for establishing priorities among these competing pavement investment options, based upon benefit-cost criteria.
- Other decision criteria (e.g., regional equity, economic development) can also be applied as adjustments to these economic results. That is, economic criteria are an important component of pavement investment decisions, but they need not be the only criteria that are used in pavement budgeting and resource allocation decisions.

4 FINDINGS ON PROGRAM MANAGEMENT

4.1 Management by Objectives

Background

Management by objectives (MBO) establishes performance goals and targets in conjunction with proposed budgets. Within the pavement program, the goals negotiated by Finnra with the Ministry of Transport and Communications, and the resulting targets negotiated between Finnra's central administration and each region, are based upon the projected quality of the pavement network. Pavement network quality is controlled in the MBO process primarily by limiting the length of substandard pavements, as tracked at a national level in Figure 1. The current pavement objective set by the Ministry of Transport is 6,400 km, as noted in Section 2.1. The value of highway infrastructure assets is also monitored.

The MBO process is implemented for the pavement program at the national governmental level and throughout the organizational levels of Finnra.

- National policy is established by the State budget passed by Parliament and expressed in objectives set by the Ministry in terms of the total length of allowable substandard pavements nationwide.
- Finnra central administration translates national objectives set by the Ministry and approved by Parliament to regional objectives, budgets, and recommended maintenance and rehabilitation actions or products, and implements these through performance agreements with each region.
- Regions pursue the pavement work program, guided by the provisions of the MBO-based performance agreements. Projects are defined, evaluated, and selected at the region level, as are the proposed methods of repair, and the work program is implemented. Progress toward the performance objectives is reported to the central administration twice a year.

Both the central administration and the regions apply management systems to assist in setting program goals and defining projects that best meet these goals. The central administration applies the HIPS system (discussed in Chapter 2.0) for strategic analysis of pavement network investments and to estimate the needed allocation of funds among regions. Regions apply a project-level system, PMS91, to assist them in defining projects and estimating future needs on particular sections of pavement. More information

on these management systems and the role they play in the MBO process is provided later in this chapter.

Operation Within Finnra

Finnra's mechanisms for translating objectives into results, and for reporting actual vs. target products and costs, for the most part appear to work well internally. Existing procedures, analytic tools, and organizational relationships provide coordination and consistency to Finnra's pavement program management in direct support of Finnra's MBO process. These capabilities are built around a number of programming elements and steps that characterize good practice in transportation agencies worldwide:

- Explicit policy objectives established by Parliament and specified by the Ministry for the pavement program. These national objectives are translated into regional program targets and are embodied in performance agreements, as noted above.
- Definition of pavement condition measures and standards that are applied for a number of purposes: i.e., to report current pavement condition; identify deficient pavement sections that may be candidates for projects; provide the data needed for performance reporting, building of historical trend lines, and updates to pavement models; and establish the basis for projection of future trends and program needs. Finnra has recently approved updated values of condition standards to provide more realistic assessments of pavement conditions and needs.
- Procedures, management systems, and other analytic tools needed by central administration and regions, respectively, to conduct strategic and project-level analyses and to identify, evaluate, and recommend projects and programs.
- Procurement procedures to translate the recommended program projects into implemented work contracts and products.
- Internal product and financial reporting to track progress, identify need for adjustment, and provide management accountability for meeting MBO cost and product targets.
- Periodic pavement inspections and customer surveys to help answer the question, "How are we doing?"

4.2 Issues Surrounding Finnra's MBO Implementation

While these steps all contribute to an MBO process that operates effectively internally within Finnra, our study has identified three issues that affect how MBO for the pavement program is perceived by those outside the road agency:

1. The need to express program objectives and measures of results in a way that is more understandable and meaningful for policy and budget discussions.

2. The need for Finnra's directors to reach a consensus on pavement management policy and to communicate that management decision in a consistent manner to parties outside of Finnra.

3. The need for a longer-term perspective in defining and evaluating projects to respond to program objectives cost-effectively.

Objectives and Measures of Results

Objectives and products of Finnra's pavement program are now gauged by the length of pavement sections that are substandard. A substandard pavement is one that fails to meet one or more engineering criteria in roughness, depth of ruts, or surface defects. By its nature, substandard pavement length provides information on only the number of kilometers of pavements in poor condition. It does not convey any information on the following questions:

- How bad are the poor or substandard pavements?
- How good are the other paved roads in the network?
- What are the consequences of pavements that deteriorate to a poor or substandard condition?

Finnra's managers in both the central administration and the regions appear to understand and are able to apply the concept of substandard pavements in their management tasks. Our interviews with managers outside Finnra, however, found this measure too technical and too limited for policy and budgeting analyses.

A better method of expressing pavement conditions, standards, objectives, and products for policy and budget development is to consider, instead, measures that describe the condition of the entire pavement network. An approach to doing this is described in Chapter 5.0.

Need for Consensus Among Finnra Management

Interviews both within and outside of Finnra indicate that Finnra's directors do not always provide a consistent view of the status of the pavement program and its implications for future investment needs. This lack of consensus inhibits the understanding outside of Finnra of the true nature of current pavement conditions, how serious a problem they represent (if any), their implications for future policy development, and their consequences for both Finnra and the motoring public, now and in the future. The confusion over whether there is a "time bomb" as discussed earlier is one example of such a situation.

Developing a consistent view on pavement management policy is a process issue that requires the following:

- Impacts of pavement policies need to be expressed in measures broader than "kilometers of substandard pavement," a recommendation that is developed further in Chapter 5.0.
- Finnra needs to proactively examine pavement management policies in terms of these broader measures expressing targets, costs, and impacts. Debate over the implications of different policies should be addressed internally within Finnra.
- Finnra's directors then need to reach a decision on the appropriate policy, and to communicate that consensus with one voice to others outside the highway agency.

Longer-Term Project Perspective

The development of pavement maintenance projects was discussed with Finnra managers and with representatives of the Finnish paving industry. Our finding is that a longer-term perspective in defining projects can reduce overall costs while meeting objectives and targets:

- Targets for pavement maintenance are now expressed as limits on substandard kilometers each year.
- Trying to meet (particularly, to maximize) an annual target encourages a greater number of shorter, more scattered project segments rather than longer project lengths that might be constructed more efficiently.
- This approach can lead to the following:
  - Higher unit costs of project work; and
  - The need to return to adjacent highway sections within a few years to repair those pavement sections that have since become substandard.

Setting pavement targets for a 3-5-year project plan, rather than annually, would encourage more effective project definition. It would provide for more efficient project lengths that, for the same activities, can be completed at lower unit cost, and that would at the same time address adjacent pavement lengths that might otherwise be due for repair within the 3-5-year window. Interpreting regional targets and work products over this multi-year period would provide regions greater flexibility in their allocation of resources among pavement maintenance, investment, and improvement needs. It would also encourage more strategic project decisions, promoting greater consistency with the economic objectives of lower long-term program costs.

4.3 Finnra's Management Systems

Finnra's highway databases and management systems provide information in support of the MBO process. They process data on the current condition of the paved network, historical trends in pavement condition, and projections of future conditions and costs. The HIPS system operates at a network level to analyze the optimal long-term and short-term investment levels subject to budget constraints and various levels of sensitivity to road user costs. PMS91 operates at the level of individual projects or sections of pavement to project future conditions, required pavement actions, and their costs. Finnra's central administration applies HIPS for strategic analyses of pavement policy, while the regions apply PMS91 for project planning and evaluation, as noted earlier. PMS91 is due to replaced by a new system, PMSpro, and Finnra is considering an update to HIPS in the near future.

Analytically, Finnra's pavement management systems are technically advanced and correspond to the state of the art among facility management systems used by other road authorities throughout the world. The PMS91 system is based upon pavement condition prediction models that have recently been updated. Our study reviewed these models and associated changes in pavement condition standards, and found them to be realistic when compared to historical trends in pavement condition among Finnra's nine regions. The optimization algorithms in the HIPS system are based

upon the economic criterion of minimum life-cycle cost, considering both (1) agency costs for long-term pavement actions, and (2) road user costs for travel time and vehicle operation as a function of pavement condition. This criterion provides an objective economic basis for evaluating pavement investment policies. Other transportation policy objectives established by the Ministry can also be considered in weighing decisions on the pavement program.

Overall, Finnra's management systems are a logical addition to, and play an important role in, the MBO process for pavements. In assessing strategic alternatives, the HIPS system enjoys credibility among policy makers as a tool that reflects societal goals regarding pavement investment. The recommendations in Chapter 5.0 for changes in the communication of pavement information should also be incorporated in the HIPS and PMS91 or PMSpro management systems to improve the value of their current reports and enhance their role in decision-making. In addition, the planned upgrade of HIPS provides an opportunity to address the following issues, of which the first has been identified by Finnra's regional managers; and the second is suggested by the findings of this study.

1. Consistency in Prediction Models

The HIPS models for prediction of pavement condition are periodically re-estimated to reflect current pavement trends, technologies, and repair practices. The models that are used in PMS91 (as well as in PMSpro and the Road Condition Data Bank) have recently been updated. The HIPS models[3] should likewise be updated to be consistent with the other pavement management tools and to correct what may be a bias in HIPS toward "light" pavement actions as observed by Finnra's regional managers. Finnra may also wish to add a feature to the model estimation procedure[4] in HIPS to enable future changes in traffic composition and associated loads on pavements to be incorporated more easily and automatically as adjustments to HIPS' pavement deterioration models. Such changes may arise, for example, as the result of increasing traffic in the East-West corridor in Southern Finland, and by modernized truck technology: e.g., the increasing use of "super single" tires.

2. Procedures, Reports, and Statistics for Policy Analyses

The HIPS algorithm provides a comprehensive analysis of network pavement condition and optimal investments. These solutions apply to both the long-term (i.e., the strategy that maintains pavement conditions at an acceptable level indefinitely) and the short-term (i.e., the strategy that provides a transition from the current paved network condition, which may have accumulated a backlog of work, to the long-term optimum). However,

---

[3] "Models" is used here generally to refer to several mathematical elements within HIPS that should be updated, including the definition of the pavement condition states, the transition probabilities that represent pavement deterioration, and the transition probabilities that represent improvements due to pavement actions.

[4] The model estimation procedure in HIPS applies inputs from the system user to estimate the values of transition probabilities that are consistent with these inputs. The procedure is known formally as the "model elicitation procedure."

not all of the information resulting from these analyses is included in the current set of HIPS reports. Additional reports should be included in HIPS to provide more complete descriptions of each policy as would be used, for example, in budget analyses and in setting objectives and targets for the MBO process. Moreover, the reports can be designed for the recommended communication of information as described in Chapter 5.0. The reports should include, at a minimum, the following statistics for both the short-term and long-term solutions, at the regional level and nationwide, and potentially by highway classification and pavement type if needed:

- Average annual expenditures and kilometers of pavements maintained.
- Kilometers or percentages of pavements in each of the condition ratings defined for the approach suggested in Chapters 5.0 and 6.0 (e.g., kilometers or percent of pavements in Excellent condition, Good condition, Fair condition, and so forth).
- The average interval, in years, between major pavement actions at a location (this should be computed as an aggregate measure for an entire network or subset thereof, not for each pavement section individually).
- The number of substandard kilometers, and the percent of the paved network that this backlog represents.
- The consequences of maintaining pavements according to the selected strategy, in terms of estimated benefits to road users (computed as reductions in user costs as compared to, for example, the current condition), and other appropriate consequences that can be identified with pavement condition.
- For the short-term solution only:
  - The average annual reduction in backlog that is needed to reach the long-term optimum, expressed either in annual kilometers or as a percent of the relevant paved network;
  - The average annual cost of this backlog reduction, in markkaa; and
  - The projected length of time to complete the short-term result and transition to the long-term strategy, in years.

5 FINDINGS ON COMMUNICATION

Reporting and communication are natural activities of the MBO process discussed in Chapter 4.0. However, Finnra managers felt that communication was a topic important enough to warrant a separate chapter in this report. First, we review the quality of the information that Finnra collects and maintains regarding the paved network, and its communication within the agency and to the Ministry and others outside of Finnra. We then propose recommendations to improve this communication, particularly to groups external to Finnra.

5.1 Current Information on the Pavement Program

The technical information now developed by Finnra regarding its pavement program serves several purposes:

- Periodic surveys provide information on the current condition of the pavement network.
- Current condition data, when added to historical records, yield trends in pavement condition over time.
- Condition data are evaluated in light of current standards or decision criteria to provide guidance to region and central administration management on what sections of pavement require maintenance or repair.
- Trends in pavement condition are compared to trends in pavement budgets or expenditures, to establish a multi-year correlation between investment levels and resulting pavement performance.

From a technical perspective, the pavement information gathered by Finnra fulfills its intended functions, particularly in expressing pavement condition and performance for use internally within Finnra. Finnra has incorporated these engineering data on pavement structural and surface condition within its condition measures and its criteria governing decisions on pavement actions. Finnra also uses these data to build the condition prediction models that are applied within its management systems. Finnra's approaches to these technical elements correspond to those used by road transportation agencies throughout the world.

The information on the paved network that is now collected, processed, and stored by Finnra in its pavement databases is accurate and credible for program management. This finding is based upon analyses of these data within a several-year period and comparisons among regions. The historical trends in pavement performance that are developed from these data are realistic, particularly when compiled by road functional classification and by pavement type. The engineering condition measures that are inferred from these data conform to typical practices for bituminous pavements by highway agencies worldwide, and the schedule of periodic inspections by Finnra's automated measurement vehicle ensures timely updates of this information.

The communication and application of pavement data within Finnra is effective. The measures of pavement condition, the associated condition standards governing each characteristic (roughness, rut depth, surface defects), and the derivation of substandard pavement length from these data are well understood by central administration and regional staffs. This comprehension is demonstrated by the widespread application of these condition data as performance measures, the inclusion of these data in management reports and publications, and the depth of specialized analyses of these data that have been conducted by regional staff. The condition states, models, and standards that are incorporated in Finnra's project-level and network-level pavement management systems likewise incorporate these engineering measures of pavement condition.

It is the communication of this information outside of Finnra that deserves attention. From a policy and budgeting perspective, however, this information has been found to be wanting, particularly as Finnra communicates this information to ministries and other groups outside the Roads Administration. In interviews conducted during this pavement program evaluation, individuals outside Finnra found the data on road

condition and its relationship to budget requests to be too technical, too complicated to understand, and insufficient for management and policy analysis. Our own assessment of this information further suggests that, while it is technically valid and useful for the purposes described above, its application to management even within Finnra could be improved.

5.2 Strengthening Communication of Pavement Policy

Experience in other transportation agencies internationally suggests that more effective approaches to developing and communicating information about pavement programs are available. These approaches help relate the technical aspects of pavement condition and performance to broader policy, budgetary, and management considerations. Furthermore, they convey useful information about the benefits or consequences of different pavement policies to both the road agency and road users. These approaches do not necessarily substitute for the technical measures and criteria that have been developed; rather, they build upon these engineering data, and help communicate information about the pavement program that is more understandable to non-technical managers and decision-makers.

Communication of policy and budget information to groups outside of Finnra can be improved through the following approach:

1. **Adopt non-technical descriptions of pavement condition that encompass the entire network, not only the substandard pavements.** Agencies typically organize these descriptions around three to five easily understood terms (e.g., Excellent, Good, Fair, Poor) that convey, succinctly, the condition of the pavements and their implications for serviceability, cost-effectiveness, remaining service life, or other consequences. Finnra has proposed such an approach in the past, as shown in Table 2, but has not yet implemented this idea in its MBO process. Table 2 illustrates how these descriptive ratings can be related to technical measures of pavement condition, providing a firm basis for linking engineering data, condition standards, and analytic models to these descriptors.[5] In addition to the relationships in Table 2, however, the descriptors should also be defined in terms that non-technical managers would understand. For example, a pavement in "Excellent" condition could be defined as one that "exhibits no structural or surface defects, provides a very smooth ride, and minimizes the costs of highway transportation to both passenger and freight vehicles."

2. **Express pavement condition, condition standards, program objectives, MBO work targets and accomplishments, and performance measures using these descriptors as much as possible.** The advantage of these descriptors is that they communicate the condition of the entire network. They convey much more information than the existing measure, length of substandard pavements. They may

[5] The values in Table 2 were established some time ago. With the recently approved changes in condition standards, the intervals corresponding to each descriptor may need to be updated. Nevertheless, Table 2 provides an example developed by Finnra of how these descriptors may be organized.

be expressed either as a length of pavement (e.g., kilometers in Excellent condition; kilometers in Good condition; etc.), or as a percent of the paved network of interest (e.g., percent in Excellent condition; percent in Good condition; and so forth). Standards, objectives, targets, and performance measures may be built around descriptors at the high end, at the low end, or both. For example, an objective could be structured as follows, using the descriptors in Table 2: "The pavement network must be kept in a condition such that at least 40 percent of the total kilometers are in Excellent to Good condition, and no more than 5 percent are in Bad condition." Or, if a backlog of needed pavement work has accumulated, a relevant policy statement may be structured as follows: "Reduce the length of Poor or Bad pavements from the current 40 percent of the paved network to no more than 5 percent in Bad condition, and 15 percent in Poor condition."

3. **Relate these descriptors to the consequences or impacts of pavement condition.** Different impacts of pavement condition will accrue to different stakeholders. For example:
   - From Finnra's perspective, pavement condition will affect future service life and the level and cost of maintenance that will be needed now and in the future. The objective of economic optimization analyses such as HIPS is to reduce the long-term sum of these costs plus road user costs (discussed in the next bullet) to a minimum.
   - From the road users' perspective, pavement condition will affect the costs and benefits of highway travel. These costs include the expenses associated with vehicle operation, a slight effect on travel time, and for freight, potentially the cost of damage to fragile cargo. If the pavement becomes bad enough to require frequent maintenance, user costs on moderately or heavily traveled highways will increase substantially due to congestion caused by the work zones.
   - From the perspective of the Ministry, pavement condition has a relationship to overall transport policy objectives for passengers and freight. These may include, for example, socioeconomic objectives relating to preserving the value of the highway assets as much and as long as possible, to objectives of economic competitiveness (relating to freight and business travel, and to personal travel for activities such as tourism).

Table 2. Descriptive Condition Ratings Defined by Finnra

Descriptor	Intervals of Roughness, IRI, mm/m	Intervals of Sum of Defects, m^2 /100 m	Intervals of Rut Depth, mm
Excellent	0.0 -- 1.3	0 -- 8	---
Good	1.4 -- 2.6	8 -- 30	0 -- 18
Fair	2.7 -- 4.1	30 -- 60	19 -- 24
Poor	4.2 -- 5.5	60 -- 120	---
Bad	>= 5.6	> 120	>=25

4. **Elements of policy formulation discussed in Chapter 3.0, and of management-by-objectives discussed in Chapter 4.0, should be coordinated to support these improvements in communication.** The following points have already been discussed, but are repeated here briefly to indicate how the several MBO and policy elements must come together to communicate a consistent message regarding pavement program needs, objectives, and consequences:
   - Proactive, not reactive, formulation and communication of the optimal pavement policy subject to realistic budget limits.
   - Clearer explanations of program needs and their relationship to paved network condition now and in the future.
   - More complete descriptions of pavement conditions, program objectives, budget needs, and consequences among different regions, classes of road users, and categories of highways, to be provided by Finnra's pavement management systems.
   - Benefits and other consequences of the recommended program investment level as compared to alternative funding levels.
   - Need for consensus and consistency among Finnra's directors in communicating the recommended program "with one voice."

6 PAVEMENT TECHNICAL INFORMATION

The focus of this report is on policy, management, and communication of Finnra's pavement program. However, since the study also included specific technical analyses and reviews, those are summarized here for completeness.

1. Pavement Condition Measures

Descriptions of pavement condition were reviewed in detail, with the following findings:

- Condition measures should be changed to a more descriptive approach (e.g., Excellent / Good / Fair / Poor / Bad) for more effective communication, as described in Chapter 5.0.
- Objectives, targets, measures of performance and results, and condition standards should all be expressed in terms of these descriptors, whether by kilometers of paved road, or percentage of the paved network.

2. Pavement Maintenance Guidelines or Criteria

Finnra has developed a comprehensive set of guidelines or decision criteria for when to perform maintenance, based upon condition standards describing the surface roughness, depth of rutting, and sum of surface defects.

- These guidelines have recently been updated to match current pavement repair practices better.
- The PMS91 project-level system models and condition standards have been updated to conform to these new guidelines. Other elements of the

MBO approach, particularly the HIPS pavement management system, should likewise be updated to conform to these new criteria.

- The guidelines or decision criteria should be expressed in terms of the descriptors summarized in Item 1.

3. Pavement Models

Models of pavement condition over time are built into Finnra's pavement management and decision support systems. Trends predicted by these models were compared to actual trends in pavement condition as obtained from the Road Condition Data Bank. Findings are as follows:

- Predicted trends of project-level models are realistic compared to actual performance when compared by pavement type (AC or SAC) and road functional class, including breakdowns by traffic volume (Average Daily Traffic, or ADT).
- Predicted pavement deterioration in the network-level model (HIPS) underestimates observed pavement damage, likely due to the following reasons:
  - The estimation procedures that yield the HIPS models include unrecorded pavement maintenance, and therefore underestimate true pavement costs.
  - The way in which projected improvement in pavement condition due to repair actions is modeled may account for regions' observations that recommended actions unrealistically favor "light" treatments.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Finnra has organized and implemented an effective process of management-by-objectives (MBO) for its pavement program. This MBO process is supported by a comprehensive and modern set of procedures and tools for pavement condition inspection, database analyses, management systems for decision support, and asset valuation. All of these elements are rooted in engineering measures of pavement condition, standards, and guidelines that are updated periodically. The study's major conclusions deal with the adequacy of the current pavement policy and budget, and how well the existing MBO procedures and tools are applied to formulation and communication of program needs:

- Current funding levels for pavement maintenance of 600-620 Mmk/yr are not optimal and will lead to a worsened paved network condition in the future.
- The appropriate investment level is 720-760 Mmk/yr over the long term, with an additional 50 Mmk/yr for 10 years needed to reduce the accumulated backlog of needed pavement work.
- Pavement program objectives, targets, and accomplishments need to be communicated more clearly and consistently by Finnra to Ministries and the public, in more easily understood and meaningful terms.

- Improvements in Finnra's pavement condition measures, models, and standards, and its current procedures for identifying projects, are needed to address program policy issues better.

7.2 Recommendations

Overall recommendations that build on the study's findings and conclusions are summarized as follows:

1. Finnra should formulate a clear pavement management policy that identifies or includes the following:
   - Short-term and long-term investment needs.
   - Impacts on pavement condition by sub-network.
   - Consequences of these resulting pavement conditions in terms of costs, benefits to passenger and freight users, and other impacts relating to broad transportation policy objectives.
   - Consensus by Finnra's directors in communicating this policy internally and externally.

2. Finnra should strengthen communication with Ministries and other groups, focusing on measures, methods, and criteria that are easily understood by a non-technical audience, that convey more complete information about the entire paved network, and that identify the consequences of funding the recommended policy as compared to impacts of other funding strategies.

3. Finnra should refine technical methods and measures in the following areas to support needed improvements in formulation, evaluation, and communication of program policy and budget recommendations:
   - Pavement condition measures and standards.
   - Relationship of pavement condition to road user costs, benefits and other impacts.
   - Consistency between network-level and project-level models, and between these models and revised threshold values of condition standards.
   - Identification of projects and evaluation of objectives and targets within a 3-5-year plan, rather than annually.

8 REFERENCES

Finnish National Road Administration, 1999. **Annual Report of the Finnish National Road Administration 1998**.

Finnish National Road Administration, 1999. **A Review of the condition standards of paved roads** (in Finnish). Draft report (to be published in 2000).

Finnish National Road Administration, 1999. **How much?** Leaflet.

Finnish National Road Administration, 1999. **Pavement Management Policies and Guidance** (in Finnish).

Finnish National Road Administration, 1999. **Road works in Finland**. Brochure

Finnish National Road Administration, 1994. **Routine road maintenance management and monitoring at the Finnish National Road Administration**.

Finnish National Road Administration, 1996. **Winter maintenance policy in Finland 1996-**.

Finnish National Road Administration, Turku Region, 1998. **Annual Report 1997**.

Jämsä H., September 15, 1999. **Asphalt Paving Needs in Finland**. Technical memorandum.

Jämsä H., 1999. **Crack initiation models for flexible pavements**. Doctoral thesis (to be published in 2000)

Lintilä J., June 18,1999. **Pavement management in Häme Region**. Technical memorandum (unpublished).

Mansukoski R., April 15, 1999. **Traffic Policy and the International Competitiveness of Industry** (in Finnish). Presented at the Annual Meeting of the Asphalt Association of Finland.

Ministry of Transportation and Communications, 1997. **Guidelines for Transport Operations until 2020**.

Ministry of Transportation and Communications, 1998. **Maintenance and improvement of transport networks, 2000-2003** (abstract in English). Ministerial working group of transport infrastructure. Report 48/1998.

Ministry of Transportation and Communications, 1999. **Welcome to the Ministry of Transportation and Communications**. Brochure.

Männistö V., 1997. **Pavement Management in Finland**. Draft report (unpublished).

Männistö V. and Tapio R., 1993. **Infrastructure Management System: Case study of the Finnish National Road Administration**. Transportation Research Record No. 1455. Presented at the 73rd Annual Meeting of the Transportation Research Board, Washington, D.C.

Männistö V. and Äijö J., 1992. **HIPS input data report** (in Finnish). Finnish National Road Administration, Report 54/1991.

Prokkola R., 1999. **Summary of PMS-seminar, September 8-9, 1999**. Technical memorandum (unpublished).

Rantanen T., 1993. **Road condition measurements and Pavement Management in Finland**. Finnish National Road Administration, Report 52/1993.

Saarinen J., Toivonen T., Männistö V. and Tapio R., 1998. **Pavement Management in Finland: Decision making from national policies to project-level programming**. Presented at the 4th international Conference on Managing Pavements, Durban, South Africa.

State Audit Office, 1998. **Improvement of road networks** (in Finnish). Audit report 11/89

Tapio R., 1999. **Allocation of resources to road infrastructure: Case example of Finland**. Prepared to the report of Performance Indicators for the Road Sector, Field Test. OECD report (to be published in 2000).

Tapio R., Piirainen A. and Männistö V., 1994. **Performance Indicators in Product-Based Management in Finnish National Road Administration**. Presented at the 3rd International Conference on Managing Pavements, San Antonio, Texas.

Virtala P. and Männistö V., 1992. **Principles of road condition classification** (in Finnish). Finnish National Road Administration, Report 36/1992.

Virtala P., Männistö., Karhula J. and Kähkönen A., 1996. **Road Management in preserving road network asset value** (in Finnish). Finnish National Road Administration, Report 66/1996.

Experts or specialists interviewed

Halme, Esa, Executive Director	Regional Council of Itä-Uusimaa
Heikkinen, Marja, Director of Finance	Ministry of Transport and Communications
Höyssä, Matti, Head of Planning	Finnish National Road Administration, Häme Region
Isotalo, Jukka, Director of R&D	Finnish National Road Administration
Jämsä, Heikki, Managing Director	Finnish Asphalt Association
Karhula, Jyrki, Head of Unit, Financial Planning	Finnish National Road Administration, Kaakkois-Suomi Region
Komulainen, Keimo, Chief of the Asphalt Plant	Finnish National Road Administration
Kuskelin, Arto, Chief of the Consultant Unit	Finnish National Road Administration
Lintilä, Janne, M.Sc. (Civ. Eng.)	Finnish National Road Administration, Häme Region
Mansukoski, Raimo, Director,	The Confederation of Finnish Industry and Employers
Mäkelä, Ville, Regional Director	Finnish National Road Administration, Kaakkois-Suomi Region
Nironen, Aulis, Director	Finnish National Road Administration
Ojajärvi, Mikko, Chief Engineer	Ministry of Transport and Communications
Parantainen, Juha, Chief Engineer	Ministry of Transport and Communications
Pietikäinen, Pertti, Managing Director	Finnish Truck Association
Prokkola, Reijo, M.Sc. (Civ. Eng.)	Finnish National Road Administration
Pukkila, Mauri, Regional Director	Finnish National Road Administration, Häme Region
Rahja, Jaakko, Managing Director	Finnish Road Association
Rantanen, Jussi, Managing Director	JJ-Asfaltti
Reihe, Mats, M.Sc. (Civ. Eng.)	Finnish National Road Administration
Ruotoistenmäki, Antti, Research Worker	Technical Research Centre of Finland (VTT)
Sälli, Kirsti, Senior Inspector	State Audit Office
Tainio, Esko, Ministerial Counsellor	Ministry of Finance
Toivonen, Tuomas, M.Sc. (Civ. Eng.)	Finnish National Road Administration
Virtala, Pertti, M.Sc. (Civ. Eng.)	Finnish National Road Administration
Weckström, Lasse, Director General	Finnish National Road Administration

9 APPENDIX

Additional Reports of the Evaluation Study

Pavement Condition. Measures, Models and Criteria. Technical memorandum. Cambridge Systematics, Inc. July 31, 1999

Trends in Asphalt Pavement Performance in Finland. Comparisons Among Regions and with Pavement Prediction Models. Technical memorandum. Cambridge Systematics, Inc. August 24, 1999

Use of the Highway Investment Programming System in Finland. Analysis of Models and Results. Technical memorandum. Cambridge Systematics, Inc. November 15, 1999

Organising, Communicating, and Applying Pavement Program Information. Review of Management-by-Objectives and Role of Finnra Management Systems, and Recommended New Ways to Communicate Information. Technical memorandum. Cambridge Systematics, Inc. January 28, 2000

ISBN 951-726-662-6